

Measurement of liquid flow in open channels —

Part 5: Slope area method of estimation

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Industrial-process Measurement and Control Standards Policy Committee (PCL/-) to Technical Committee PCL/3, upon which the following bodies were represented:

- Clyde River Purification Board
- Department of the Environment
- Department of the Environment for Northern Ireland
- Institute of Measurement and Control
- Institution of Water and Environmental Management
- National Rivers Authority
- Water Services Association of England and Wales
- Welsh Office

The following body was also represented in the drafting of the standard, through subcommittees and panels:

- Water Research Centre

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National foreword

This British Standard has been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee. It supersedes BS 3680-5:1970 which is withdrawn. It is identical with ISO 1070:1992 *Liquid flow measurement in open channels — Slope-area method* and its amendment 1:1997, published by the International Organization for Standardization (ISO).

This standard is one of a series of Parts of BS 3680 on the measurement of liquid flow in open channels.

Cross-references

International Standard	Corresponding British Standard
ISO 1100-2:1982	BS 3680 <i>Measurement of liquid flow in open channels</i> Part 3C:1983 <i>Methods for determination of the stage-discharge relation</i> (Identical)
ISO 5168:1978	BS 5844:1980 <i>Methods of measurement of fluid flow: estimation of uncertainty of a flow-rate measurement</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 772:1988 and of ISO 4373:1979, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to ISO 772 is BS 3680-1:1983. BS 3680-1 has since been revised, and is now published as BS 3680-1:1991. A revision of ISO 772 is in preparation.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This International Standard specifies a method of determining liquid flow in open channels from observations of the surface slope and cross-sectional area of the channel. It is suitable for use under somewhat special conditions when direct measurement of discharge by more accurate methods, such as the velocity-area method, is not possible.

The slope-area method can be used with reasonable accuracy in open channels having stable boundaries, bed and sides (e.g. rock or very cohesive clay), in lined channels and in channels with relatively coarse material. It may also be used in alluvial channels, including channels with overbank flow or non-uniform channel cross-sections, but in these cases the method is subject to large uncertainties owing to the selection of the rugosity coefficient (such as Manning's coefficient n or Chezy's coefficient C).

Generally the method may be used to determine discharge

- a) at the time of determining gauge heights from a series of gauges;
- b) for a peak flow that left marks on a series of gauges or where peak stages were recorded by a series of gauges;
- c) for a peak flow that left high-water marks along the stream banks.

This method is not suitable for use in very large channels, channels with very flat surface slopes and high sediment load or channels having significant curvature.

Although the accuracy of the results given by the slope-area method is less than that of the results given by the velocity-area method, the slope-area method is sometimes the only method that can be used for determining the extreme high-stage end of rating curves in cases where the magnitude of floods is such that other methods of measuring discharge cannot be used.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols*.

ISO 1100-2:1982, *Liquid flow measurement in open channels — Part 2: Determination of the stage-discharge relation*.

ISO 4373:1979, *Measurement of liquid flow in open channels — Water level measuring devices*.

ISO 5168:1978, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 772 apply.

4 Principle of the method of measurement

A measuring reach is chosen for which the mean area of the stream or river cross-section is determined and the surface slope of the flowing water in that reach is measured. The mean velocity is then established by using known empirical formulae which relate the velocity to the hydraulic mean depth, and the surface slope is corrected for the kinetic energy of the flowing water and the characteristics of the bed and bed material. The discharge is computed as the product of the mean velocity and the mean area of the stream cross-section.

5 Selection and demarcation of site

5.1 Initial survey of site

It is recommended that approximate measurements of widths, depths and surface slopes should be made in a preliminary survey to decide whether the site is suitable and conforms, as far as possible, with the conditions specified in 5.2 and 5.3. These measurements should serve as a guide only.

5.2 Selection of site

5.2.1 There should be no progressive tendency for the river to scour or to deposit sediment.

5.2.2 Ideally, the river reach should be straight, and should contain no large curvatures or meanders. There should not be any abrupt change in the bed slope in the measuring reach, as can occur in rocky channels. The cross-section should be uniform throughout the reach and free from obstructions. Preferably, vegetation should be minimal and as uniform as possible throughout the reach.

5.2.3 The bed material should be similar in nature throughout the reach.

5.2.4 Wherever possible, the length of the reach should be such that the difference between the water levels at the upstream and downstream gauges should be not less than ten times the uncertainty in the difference. When the uncertainty in the measurement of the water level at each gauge is similar, then the distance between the gauges should be sufficient for the fall to be not less than twenty times the uncertainty in measurement at one gauge.

5.2.5 The flow in the reach should be free from significant disturbances due to the effect of tributaries.

5.2.6 The flow in the channel should be contained within defined boundaries. If possible, reaches in which overbank flow conditions exist should not be selected. Where this is unavoidable, however, a reach in which there are no very shallow flows over the flood plain should be sought, but additional computations will be necessary in the determination of discharge.

5.2.7 The site should not be subject to change in the flow regime from subcritical to supercritical or from supercritical to subcritical (but see **10.6**).

5.2.8 A converging reach should be selected in preference to an expanding reach. Rapidly expanding reaches should not be selected (see **10.4**).

5.2.9 The physical characteristics of the reach should be such that the time lag of flow in the reach may be negligible.

5.3 Demarcation of site

Once the measuring reach has been selected, cross-sections normal to the direction of flow shall be chosen and markers which are clearly visible and identifiable shall be placed on both banks (see also **9.1**). A reference gauge, levelled to a standard datum, shall be installed (see **6.1**).

The site should be monitored to ensure that no physical changes occur which render it unsuitable. If changes do take place and the site cannot be successfully restored, a new site should be selected.

6 Devices for measurement of slope

6.1 Reference gauge

The reference gauge shall comprise a well gauge, where feasible, preferably incorporating a vertical gauge rather than an inclined gauge. The vertical gauge (or inclined gauge) shall comply with ISO 4373. The markings shall be clear and accurate and shall cover the range of stage to be measured.

The reference gauge shall be securely fixed to an immovable and rigid support in the stream and shall be correlated to a fixed benchmark by precise levelling to the national or another datum.

6.2 Water-level recorder

Water-level recorders (if used) shall comply with ISO 4373.

6.3 Crest stage gauge

A crest stage gauge is suitable for use where only the peak stage attained during a flood has to be determined. Peak discharges can be calculated from two or more gauges installed in a reach of the river, at locations suitable for defining cross-sectional profiles.

6.4 High-water marks

The stage and slope of peak flows can be determined by surveying high-water marks in the measuring reach. Several types of high-water mark may be found, such as drift on banks, wash lines, seed lines on trees, mud lines, and drift in bushes or trees. Each high-water mark should be rated as excellent, good, fair or poor. This information will be helpful when interpreting the high-water profile and slope.

7 Procedure for installing gauges and making observations

7.1 Installation

Gauges shall be installed, on both banks of the river, at no fewer than three cross-sections, making a total of at least six gauges. The gauges shall be referenced to a common datum.

7.2 Procedure for observation of gauges

The gauges shall be read from such a position as to avoid all parallax errors. For each measurement, the gauge shall be observed continuously for a minimum period of 2 min or for the period of a complete oscillation, whichever is the longer, and the maximum and minimum readings taken and averaged.

When using water-level recorders, an observer should check the time displayed on each recorder against an accurate clock before and after the measurement period and also during the measurement period. All gauges should be observed as frequently as is necessary to record significant changes in stage which occur during the measurement period.

7.3 Other observations

The date, time, weather conditions (especially wind speed and direction), direction of the flow, and conditions of vegetation at the time of measurement should be recorded.